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CENTRAL INTELLIGENCE AGENCY

INFORMATION REPORT

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SECURITY INFORMATION

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COUNTRY USSR (Kalinin Oblast)

SUBJECT Supplementary Information on the Entry Trajectory of the R-14 Missile with Increased Drag Coefficient, Used at Branch No. 1, Plant 88 on Gorodomlya Island

DATE OF

PLACE ACQUIRED

REPORT

DATE DISTR. 4 December 1953

NO. OF PAGES 11

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REQUIREMENT

REFERENCES

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THE APPRAISAL OF CONTENT IS TENTATIVE.
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DATE DISTR. 30 OCT 53

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NO. OF PAGES: 10

PLACE ACQUIRED :

NO. OF ENCLS. (LISTED BELOW)

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DATE ACQUIRED

SUPPLEMENT TO REPORT NO.

DATE OF INFORMATION :

THIS IS UNEVALUATED INFORMATION

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ALBRING's Formula for the Aerodynamic Heating of Missiles upon Re-entry, as used at Branch No. 1, Plant 88 on Gorodomlya Island (SCHULZ)

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Supplementary Information on the Entry Trajectory of the R-14 Missile with Increased Drag Coefficient used at Branch No. 1 of Plant 88 on Gorodomlya Island (SCHULZ)

1. In the study pertaining to the aerodynamic heating of rockets 50X1-HUM examined an entry trajectory for the R-14 at an altitude of 100 km. using the following data: 50X1-HUM

$t=0$, $H=100$ km., $v=4{,}500$ m/sec., $\gamma = -38^{\circ}38'$

The trajectory thus calculated was based on an angle of attack of zero. Upon entry into the denser atmosphere the missile (warhead) will oscillate giving rise to an angle of attack of varying magnitude. This causes an increase in the drag (resistance) coefficient because an induced drag element will be added to the components wave, friction, and suction drag. This increase in the drag coefficient will lead to changes in the trajectory values.

2. 50X1-HUM discussed below the influence on the trajectory due to an increase in the drag coefficient. 50X1-HUM not study the process of oscillation, nor calculate the angle of attack and the determination of the drag coefficient in dependence on the angle of attack, but instead 50X1-HUM approached the problem by examining in addition to the trajectory described above, two other trajectories which have assigned drag coefficients 50 per cent and 100 per cent greater than the original one. The trajectories with the greater drag coefficients were calculated in the same manner and with the same initial values as of 100 km. altitude as the original R-14 trajectory. The three trajectories will be denoted as follows:

Case a: Trajectory, R-14 discussed above

Case b: Increase of drag coefficient by 50 per cent

Case c: Increase of drag coefficient by 100 per cent

The drag coefficients are:

Case	a	b	c
Ma		c_w	
(1)		(1)	
9	0.0696	0.1044	0.1392
12	.0641	.0962	.1282
15	.0616	.0942	.1232

The results of these calculations are shown on the charts at the end of this report /see pages 5, 6, 7, 8, 9, and 10/. In these charts:

Case a is shown as: ——————

Case b is shown as: — · — · — · — ·

Case c is shown as: — — — — — — — —

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3. In the first twenty seconds from an altitude of 100 km. to approximately 40 km. the differences in air resistance for the three trajectories are so small that the speed and the altitude coincide for the three cases. Gradually, the loss of speed as a result of greater air resistance is noted, and by t=30 sec. the following values are obtained:

Case	t (sec)	v (s/sec)	H (km)	ϑ
a	30	4487	11.61	-41°24'
b	30	4397	11.74	-41°24'
c	30	4311	11.88	-41°25'

The differences in the speed from one trajectory to the next amount at this time to approximately 90 m/sec. The difference in altitude amounts to between 130 and 140 m. In the horizontal distance X the differences amount to 150 to 170 m. at t=30 sec. The differences will now begin to increase rapidly for the same time intervals. The first three charts [pages 5, 6, and 7] show this increase for v, H and X.

4. The flight time (i.e., up to impact on the ground) increases from trajectory to trajectory by approximately 0.3 seconds. The values at the moment of impact are as follows:

Case	t (sec)	v (m/sec)	ϑ
a	34.18	3800	-41°49'
b	34.46	3403	-41°52'
c	34.78	3035	-41°56'

Although the differences for the impact speed amount to nearly 400 m/sec., the trajectories in themselves differ only very little. The angle of impact differs only by 3' or by 4' respectively. The result is that the difference in range becomes very small. The third chart [page 7] shows that the slower trajectories obtain approximately the old range because of the increased flight time. The differences from trajectory to trajectory amount to less than 50 m. In regard to X, it should be noted that the zero-point is at t=0, where H=100 km. and that the curvature of the earth was neglected. The fourth chart [page 8] shows the end of the trajectory for the case a and c, whereby the points t=33 sec. and t=34 sec. have been emphasized.

5. Heat calculations were made for cases b and c in the same manner as earlier for case a. That is, the skin temperature was calculated by means of the approximate formula. (No comparison was made with the results obtained using Lo's formula.) The results of these calculations are shown in the fifth and sixth drawings [pages 9 and 10] in which the boundary-layer temperature (T_B) and the skin temperature (T_S) for the last seconds of flight are presented. While the differences in boundary-layer temperature at t=30 sec. amount to 250°C from trajectory to trajectory, the skin temperature differences are small, amounting to only 15°C. The values are as follows:

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Case	t (sec)	T_B ($^\circ$C)	T_S ($^\circ$C)
a	30	7030	603
b	30	6760	589
c	30	6510	577

At the moment of impact, the differences in the skin temperature from trajectory to trajectory amount to 80° to 85°C. The values for the boundary-layer and the skin temperature are:

Case	t (sec)	T_B ($^\circ$C)	T_S ($^\circ$C)
a	34.18	5190	1360
b	34.46	4240	1280
c	34.78	3430	1195

6. Of interest--from a standpoint of strength studies--is the increase in the air drag and the stagnation pressure. The following are the values at t=30 sec. and at the time of impact:

Case	t (sec)	W (to)	q (to/m^2)
a	30	32.3	341
b	30	45.6	320
c	30	57.4	301

Case	t (sec)	W (to)	q (to/m^2)
a	34.18	90.3	902
b	34.46	112.5	724
c	34.78	123.7	576

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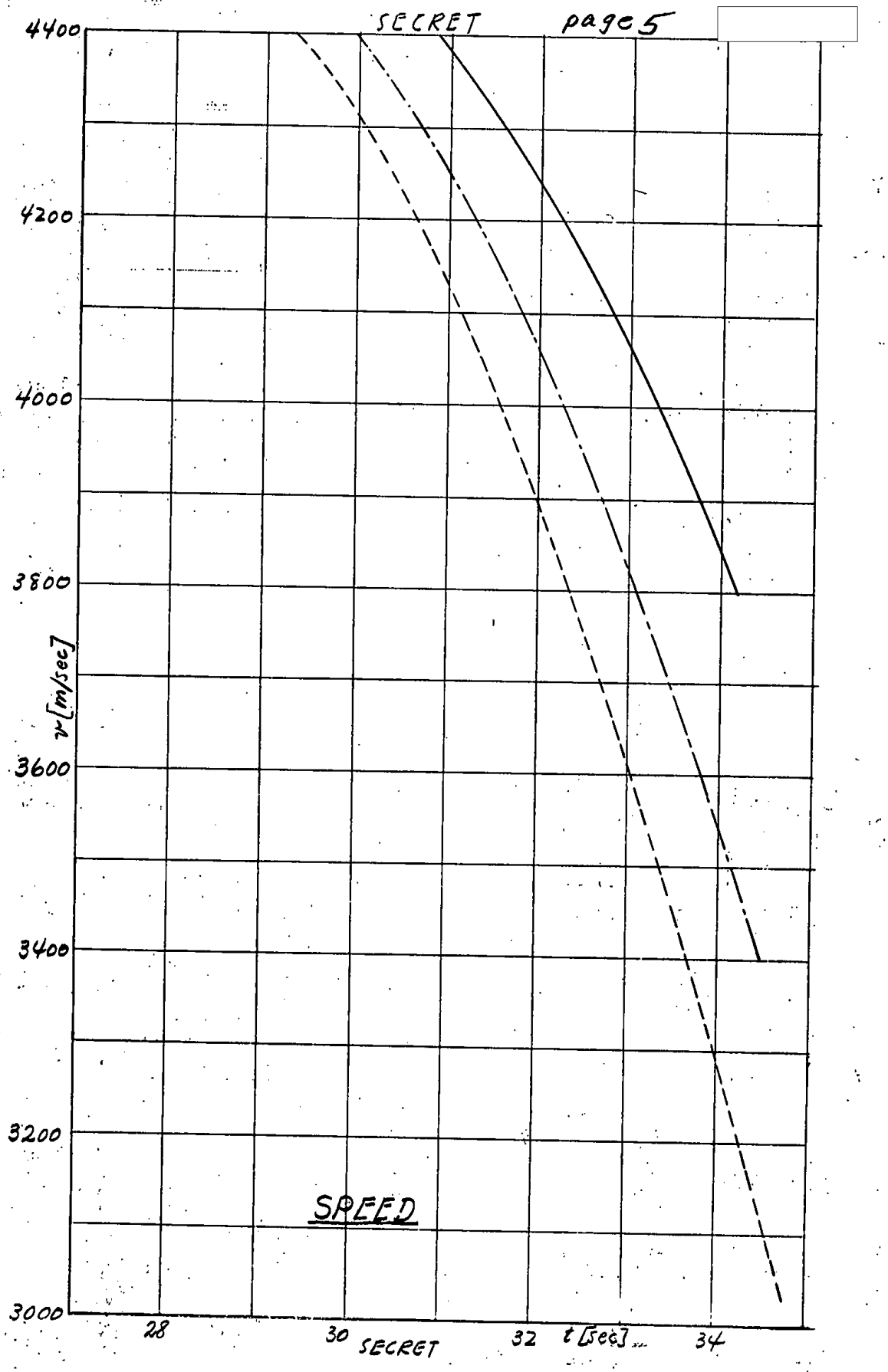

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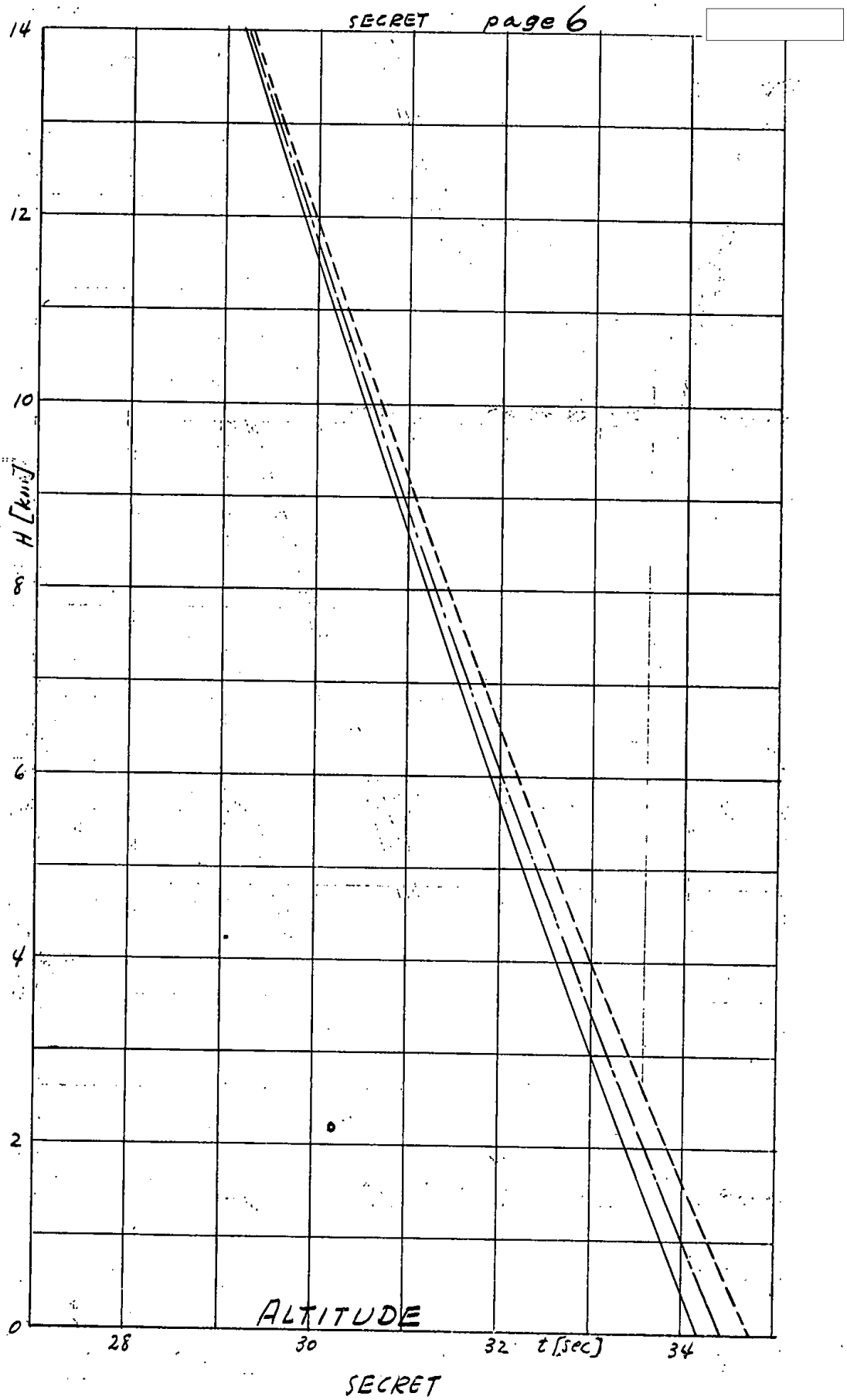

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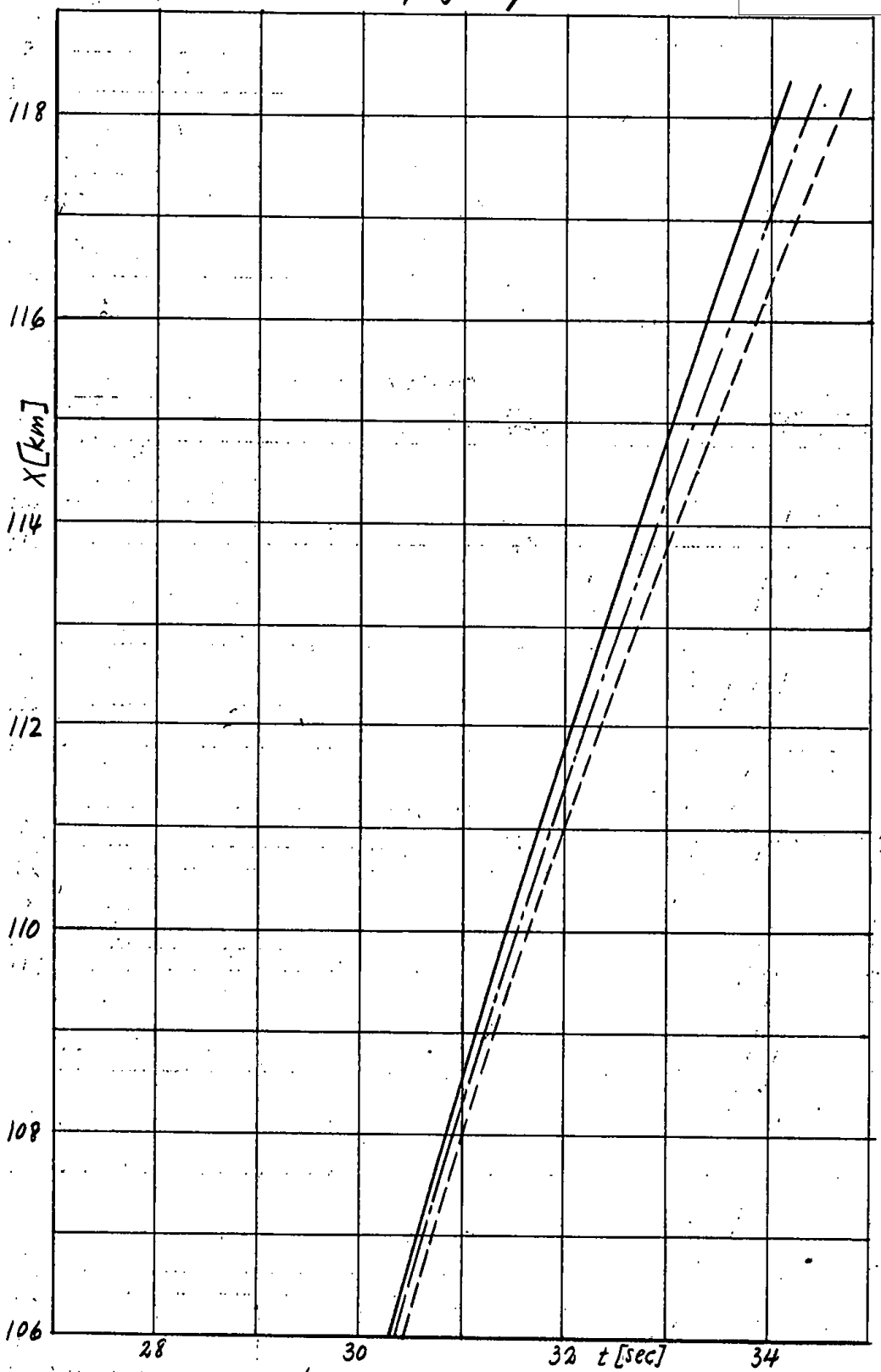

HORIZONTAL DISTANCE

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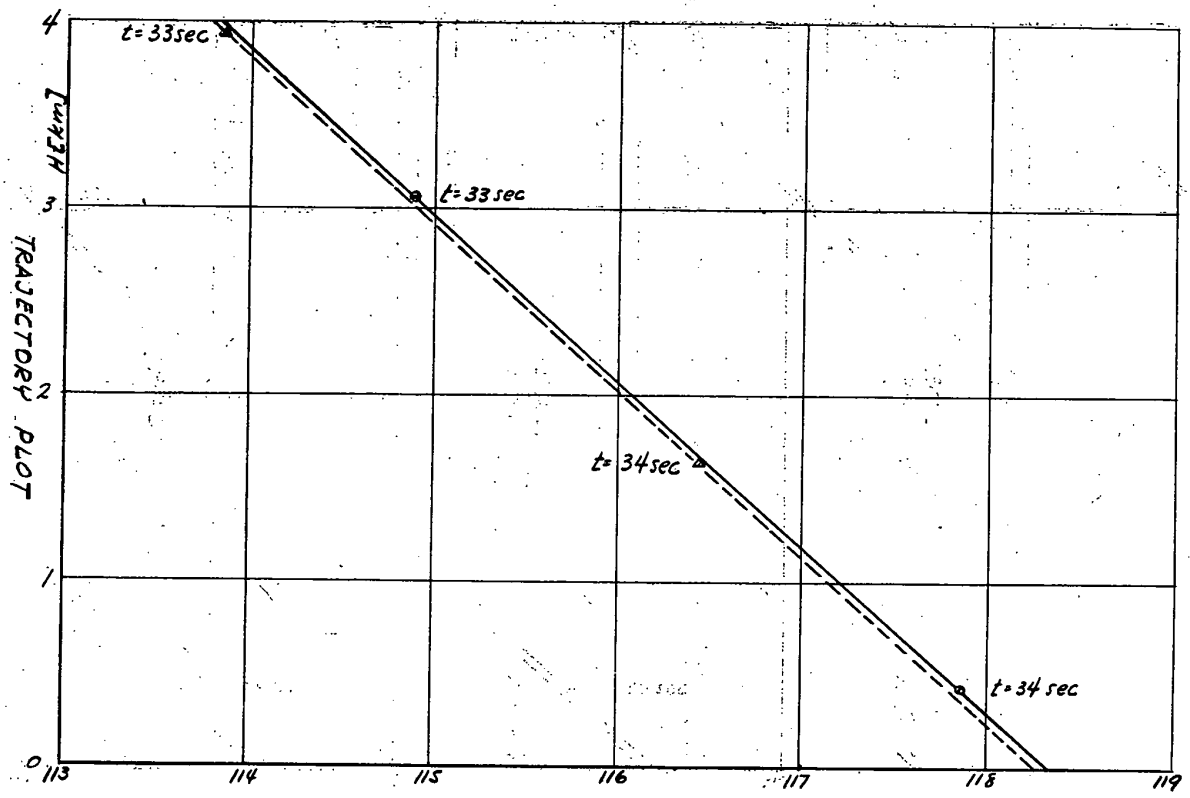

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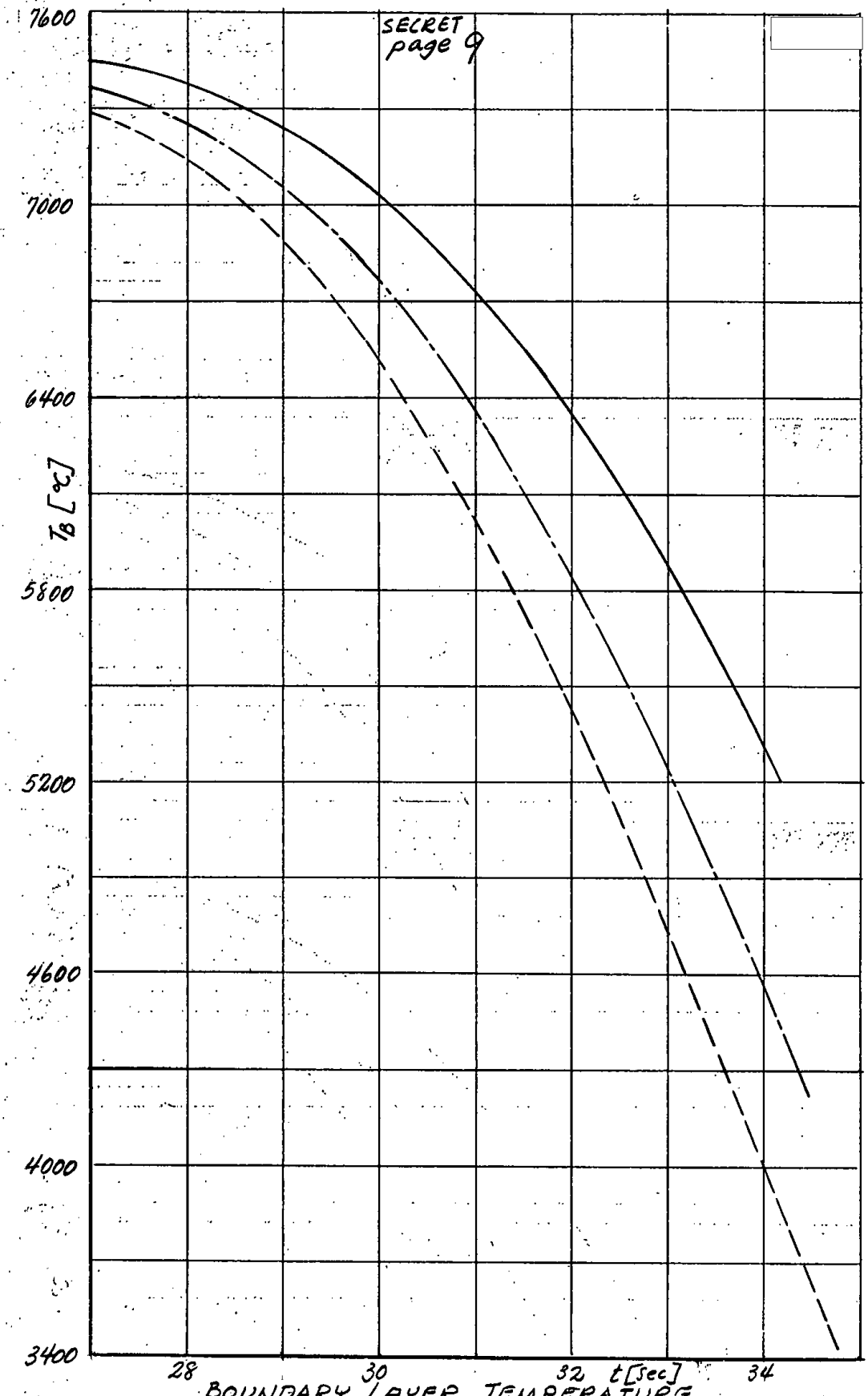

BOUNDARY LAYER TEMPERATURE

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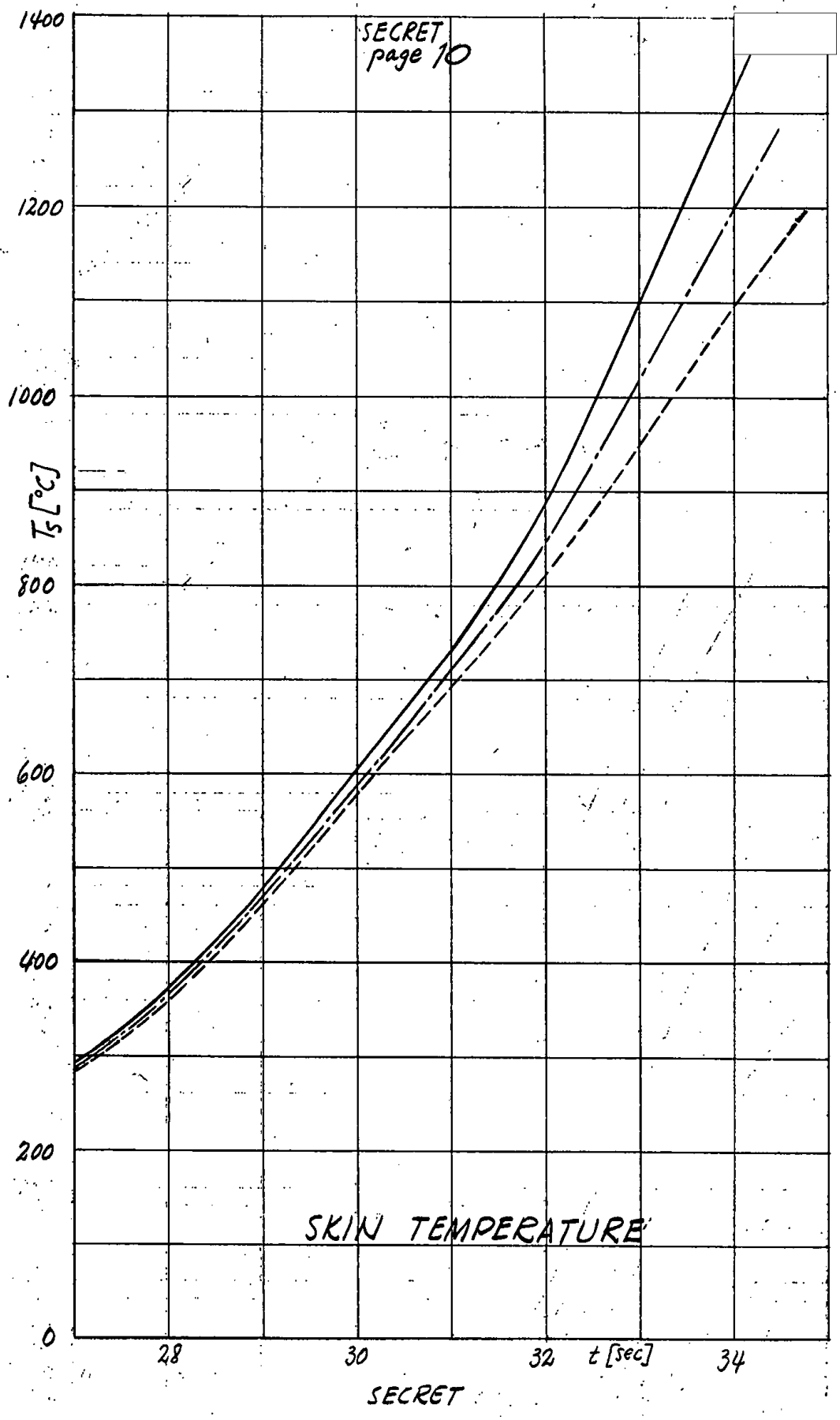

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